Protocol: NCCN Mountain Lakes and Ponds Protocol Development Summary *(R. Glesne revision 07/20/05)*

Vital Signs: Water Quality and Nutrients, Water Temperature, Fish, Amphibians, and Habitat
Parks: NOCA, MORA, (EBLA and LEWI at selected sites)

Justification:

Mountain lakes and ponds serve as integrator sites for impacts occurring in their watersheds, and consequently may be the most economically efficient sites to detect early warning signals for some non-point pollutants. In wilderness areas of the western United States most lakes and ponds are particularly susceptible to effects associated with the deposition of air borne pollutants, global climate change, and land use practices on adjacent lands (Eilers *et al*. 1994, Cole and Landres 1996). Recent studies have documented the presence of persistent organic pesticides and mercury in mountain lakes in NOCA and MORA (Moran and Black, in prep). Recreational impacts on and near aquatic systems are often more extensive than on adjacent terrestrial areas because lakes and ponds tend to attract certain types of high impact recreational activities such as camping and fishing (Cole and Landres 1996). Stocking fish into mountain lakes of the western U.S. to increase recreational fisheries has been implicated in reduced amphibian abundance and distribution as well as for several zooplankton and benthic macroinvertebrate species (Tyler *et al*. 1998, Liss *et al.* 1999, Knapp and Matthews 2000, Knapp *et al*. 2001, Larson and Hoffman 2002). Historically, there has been extensive fish stocking into previously fishless lakes and ponds within the NCCN. At NOCA, a total of 150 lakes (of 554 lakes and ponds in the park complex) are regarded as capable of supporting fish populations**.** Ninety-five of the 150 lakes have been stocked in the past. No MORA lakes are known to have naturally supported fish populations, however extensive stocking was conducted up to 1972. Thirty park lakes still support reproducing populations of these introduced trout. Fish were historically absent from OLYM high country lakes, but were introduced there as in MORA, and continue to survive in an unknown number of lakes.

Primary stressors that affect Network montane lakes and ponds include global climate change, air pollution (metals, pesticides and other semi-volatile organics, acidification, nutrient deposition), visitor disturbances, and introduction of non-native fish species. Many of these stressors will be intensified in the future by the rapid expansion of the population in the Pacific Northwest. The proposed indicators of lake and pond ecological condition are directly related to 6 of the top NCCN vital sign priorities.

Monitoring Questions and Objectives:

Monitoring Questions

- What are the status and trends of the ecological condition of small lakes and ponds in the Parks? (As measured by key biological, chemical, and physical indicators- see Table 1.)
- How are climate change and air quality related impacts affecting the ecological condition of lakes and ponds?
- Are non-native fish species expanding their abundance and distribution, and what are effects on native biota (zooplankton, macroinvertebrates, and amphibians)?
- Is visitor use related disturbance increasing and what are the effects on the ecological condition of lakes and ponds?

Objectives

For a randomly selected subset of mountain ponds and lakes in the parks;

1. Determine the natural variation and long term trends in selected physical, chemical and biological water quality parameters in reference lakes/ponds.

2. Determine the status and trend of amphibian assemblages in focal lakes.

3. Determine long-term trends in the abundance and condition of non-native fish assemblages in selected reference lakes.

4. Document trends in direct effects of visitor use on shoreline condition for the reference lakes.

Methods:

Sampling Design

Applications of inferential parkwide sampling designs require a minimum number of sample sites in order to maintain a representative sample of the target population. Participants of the USGS-NPS Lake Monitoring Workshop (2002, Corvallis OR) recommended a sample size of 20 to 30% of the target population. With the objective of a parkwide trend evaluation at NOCA and MORA, a subset of all of the lakes and ponds in the parks is required to meet the limitations of the proposed implementation budgets. In addition, a split-panel rotating design is required to enhance the overall number of sites visited, however at the expense of increasing the sampling interval between site revisits at some sites. Application of these two approaches will allow us to meet the sample size criteria, with some sites sampled annually and others sampled on a 5-year rotation. Considering the latter, the target populations for MORA and NOCA were reduced to include only perennial lakes and ponds greater than 0.2 ha. in surface area. This reduced the number of sites in the sample frame at each park from over 300 (>500 at both NOCA and MORA if ephemeral ponds are included), to 178 at NOCA and 140 at MORA. The sampling frames represent montane, subalpine and alpine zones of the parks, although most of the lakes are found in the subalpine zone.

The GRTS spatially balanced sampling program (Stevens and Olsen 1999) was used to select a random sample with equal probability of selection. Logistical and budget constraints will allow for a total annual sampling effort of 12 sites/year at MORA and 11 sites/year at NOCA. The split-panel design includes one panel sites (NOCA = 5 sites and MORA = 6 sites) sampled every year, and 5 panels of sites (6 sites at NOCA and MORA) sampled on a 1 year on and 4 years off rotation. Total sample sizes for the 5-year rotation equals 36 sites at MORA and 35 sites at NOCA.

Although there are no mountain lakes and ponds at EBLA and LEWI, there are a few lowland ponds that are included in the network program. Because of the limited number of lakes and ponds at EBLA and LEWI, only 1 to 3 representative sites will be selected at each park and sampled annually.

Sampling Components and Methods

The most efficient and informative approach is to integrate the various stream vital sign components and measures (Table 1.) into a comprehensive lake and pond protocol. From a logistical standpoint, the difficulty of accessing sample areas represents a large fraction of the cost of the program, with travel to and from sites taking up to two days. Integrated data collection of complimentary parameters allow for a composite analysis of lake and pond condition as well as individual analyses of key NCCN vital signs.

Table 1. Mountain lakes and ponds vital signs and measures.

Network Vital Sign	Measures
Lake physical characteristics	Surface area and perimeter, inlets and outlets, lake water level, mean and maximum depth, Secchi transparency, littoral zone area, nearshore substrate composition and large woody debris, nearshore zone % veg. cover by type, nearshore zone disturbance, and reference photos.
Water quality - Temperature	Continuous annual monitoring with data loggers surface, middle, and bottom - Daily max, min, mean, also used to calculate: Max Weekly Ave Temp, Min Weekly Ave Temp, Max Weekly Max Temp, Max Weekly Change in Temp, and Monthly Mean Temp.
Water quality - chemistry	Dissolved oxygen, specific conductivity, pH, acid neutralizing capacity, total dissolved solids, dissolved organic carbon, chlorophyll a, ammonia, nitrate, total Kjehldahl nitrogen, total phosphorus, sulfates, and other selected anions and cations.
Aquatic macrophtyes	Presence/absence of exotics, % cover
Zooplankton	Species richness, relative abundance, compositional metrics, indicator taxa, ratio of observed taxa versus expected taxa.
Macroinvertebrates	Frequency/abundance of indicator taxa, average metric scores (compositional, functional, dominance, species richness and tolerance metrics), multi-metric index scores, ratio of observed taxa versus expected taxa.
Amphibians	Proportion of sites occupied by species, relative abundance, distribution, and size composition
Fish	Proportion of sites occupied by native and non-native species, relative abundance, distribution, and size composition.
Land cover and land use **(NOTE: separate NCCN protocol)**	Landsat imagery and aerial photos – Catchment scale changes in vegetation and catastrophic disturbances, trends in snow cover, and lake ice-out.

All sites selected for sampling in any given year will be visited at least once during August – September. An additional visit during June- July may be accomplished depending on funding and access constraints. Methods for most components will generally follow those developed by the USGS BRD in Corvallis (Hoffman *et al*. 2005, http://water.usgs.gov/pubs/tm/2005/tm2a2) with modifications as necessary to meet sampling constraints at each park.

Evaluation of monitoring results will be facilitated by tracking site-specific changes in baseline conditions, using existing criteria (State and USEPA), and unimpaired reference site information

where available. Information from monitoring will be incorporated in the development of new or refined criteria and/or reference site information to be used for assessing impairment and setting triggers for management actions (Lake and pond aquatic macroinvertebrate criteria are currently being developed for NOCA and MORA). Status reports will include basic summary statistics and use of cumulative distribution frequencies. Cumulative distribution frequencies will represent the values of output variables in relation to criteria and summarized by area of lakes, number of sites, percent of sites occupied, etc.

Methods for evaluation of within site and parkwide trends are currently being developed by Dr Trent McDonald (WEST, Inc., Laramie, WY) and Robert Hoffman (USGS-BRD, Corvallis OR) and will generally follow methods described and discussed in Larsen *et al*. (2004).

Principal Investigators and NPS Leads:

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Development Schedule, Budget and Expected Interim Products:

Schedule

May 2005
- USGS-BRD Mountain Ponds and Lakes Protocols completed

August 2005
- NCCN sampling design and sample frame development completed for MORA and NOCA.

December 2005
- Report on USGS-BRD protocol field testing at MORA

January 2006
- Draft NCCN Mountain Lake and Pond Protocol completed (excluding data management and analyses)

March 2006
- Draft data evaluation protocols completed.
- Draft data management protocols completed.

May 2006
- Final NCCN Mountain Lake and Pond Protocol completed and peer reviewed. August 2006
- Implementation of wadeable stream protocol (NOCA and MORA)

March 2007
- Completion of report on MORA and NOCA lake and pond macroinvertebrate metrics, observed/expected predictive model, and criteria for assessing impairment.

Implementation Operational Budget (not including ONPS funded positions)

	NOCA	MORA	OLYM*	Sm. Parks**	Total
NCCN Budget	**$25,550**	**$25,600**	**$22,770**	0	**73,920**

* See separate Protocol Development Summary for OLYM (final protocol will include all NCCN parks)

**use an additional $1100 of Water Resource Funds for 2 sites at LEWI and $500 for one site at EBLA for a total of $1600 obligated to small park lakes and ponds.

Annual Program Schedule

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Field prep/train						X	X					
Sampling							SP	X	X			
Data mgt. and sample processing									X	X		
Data analysis											X	X
Reporting	X	X										

SP – Small parks sampled in July

Literature Cited:

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